

Force calculations on Opera models of SOLID magnet system

Jay Benesch
2 December 2016

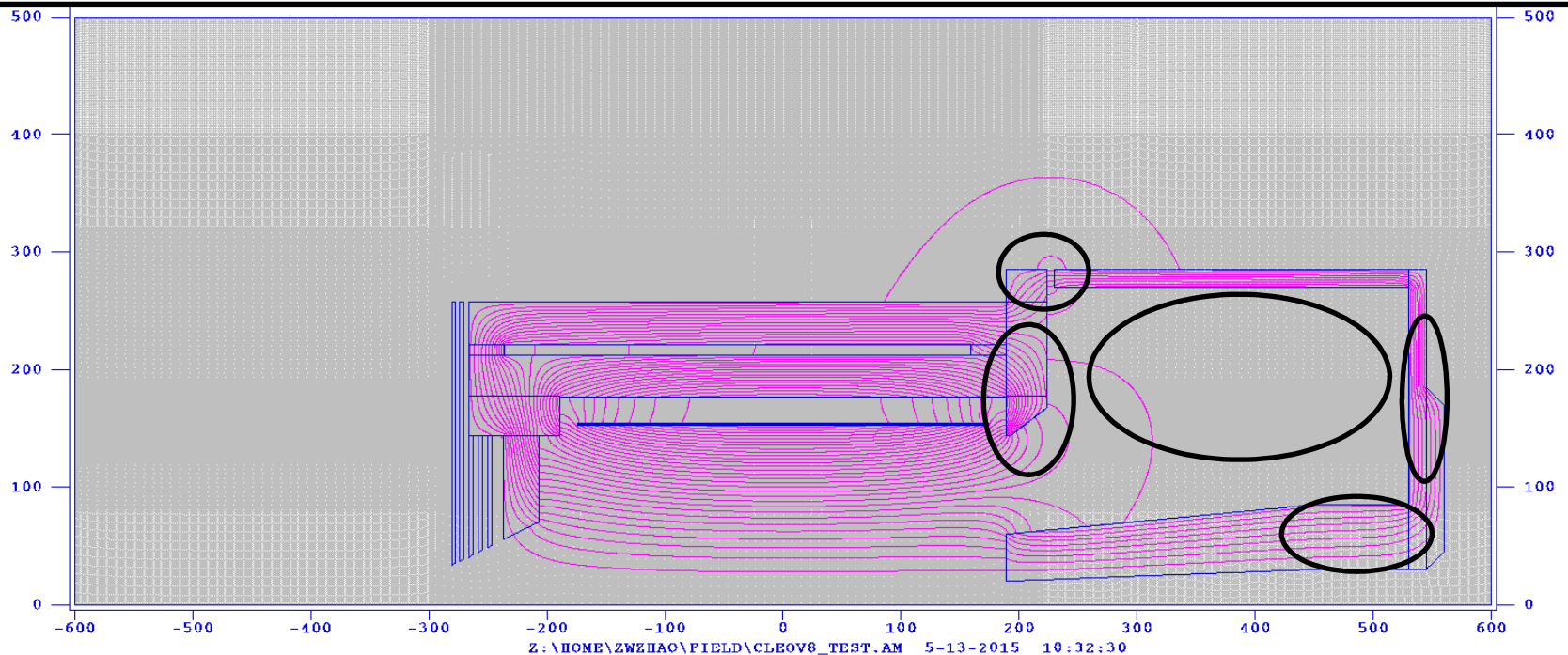
Zhiwen's suggestions

Just ideas, but changes are definitely needed

- Downstream collar enlarge by 15cm in z (engineering need for support)
- Endcap move 15cm downstream and enlarge 30cm (SIDIS setup needs room)
- Endcap nose back reduce 5cm in r (EC hexagon module needs room)
- 6cm gap between downstream collar and endcap (let cable out, more cable out at back needed)
- Main impact, PVDIS EC large angle performance

Need design with full 3D model and satisfy both physics and engineering requirement needed by all subsystems to fix their design, must be a coherent effort

More realistic design now, More saving of man power, effort, cost, maybe even physics



My current baseline

22/Oct/2016 08:07:58

Surface contours: BMOD

2.950202E+04

2.500000E+04

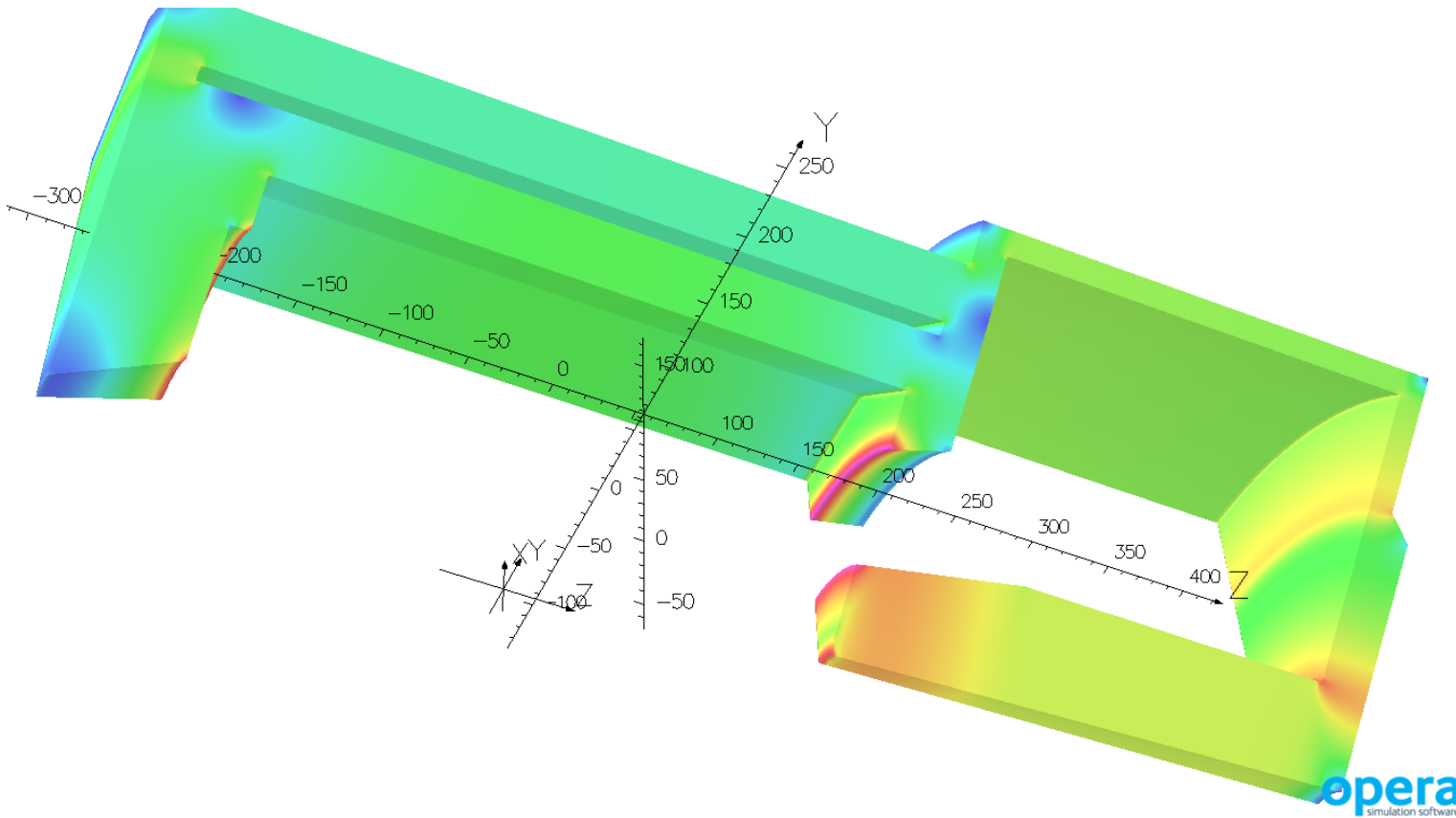
2.000000E+04

1.500000E+04

1.000000E+04

5.000000E+03

2.351515E+01



UNITS	
Length	cm
Magn Flux Density	gauss
Magnetic Field	oersted
Magn Scalar Pot	oersted cm
Current Density	A/cm ²
Power	W
Force	N

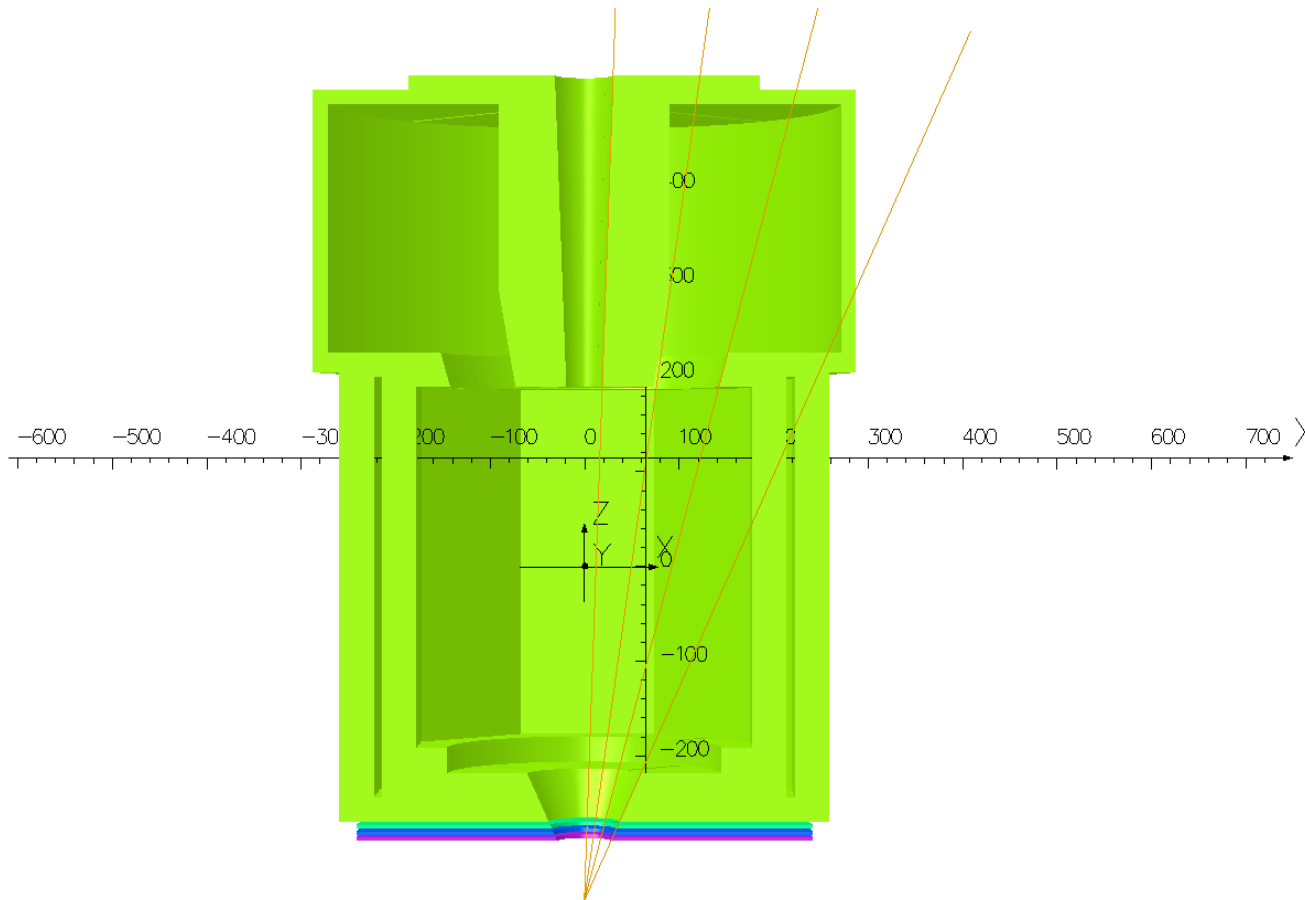
MODEL DATA
solid_r20f_66cm_chamf.op3
Magnetostatic (TOSCA)
Nonlinear materials
Simulation No 1 of 1
23562323 elements
25388102 nodes
3 conductors
Nodally interpolated fields
Activated in global coordinates
8-fold rotational symmetry

Field Point Local Coordinates
Local = Global

Upstream plug is 26" with 24 degree conical hole. Downstream coil collar is 14" thick. Net force on coil 23 kN vs 196 kN allowable. ~100 cm OD by ~6 cm Z upstream solenoid to null stray field for He3

SIDIS angles: 2, 8, 14.7 and 24 degrees from (0,0,-350)

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UNITS
Length cm
Magn Flux Density gauss
Magnetic Field oersted
Magn Scalar Pot oersted cm
Current Density A/cm²
Power W
Force N

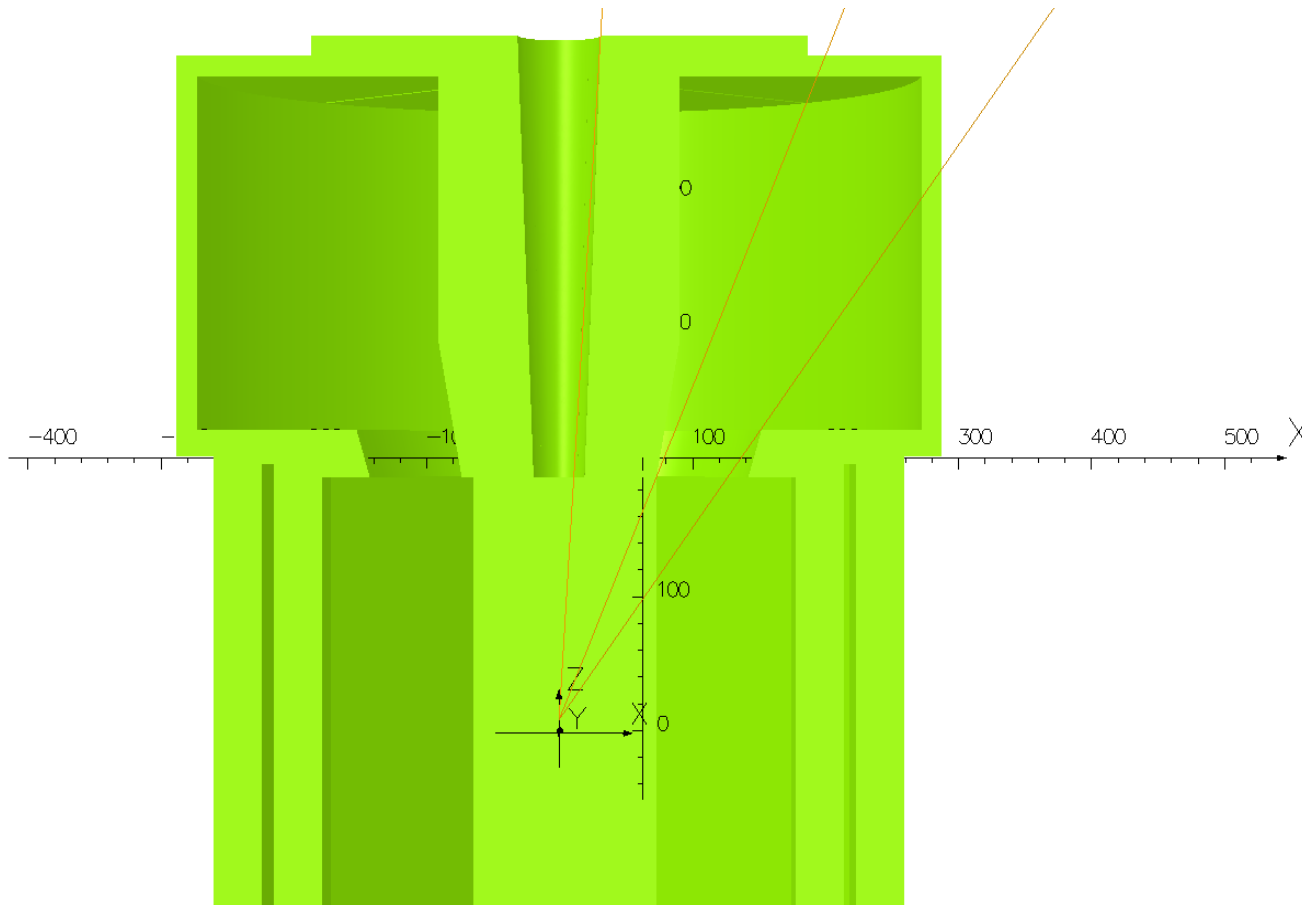
MODEL DATA
solid_r20a.op3
Magnetostatic (TOSCA)
Nonlinear materials
Simulation No 1 of 1
23979099 elements
25707022 nodes
3 conductors
Nodally interpolated fields
Activated in global coordinates
8-fold rotational symmetry

Field Point Local Coordinates
Local = Global

opera
simulation software

PVDIS angles: 3.5, 22 and 35 degrees from (0,0,10).

19/Oct/2016 06:51:12



UNITS
Length cm
Magn Flux Density gauss
Magnetic Field oersted
Magn Scalar Pot oersted cm
Current Density A/cm²
Power W
Force N

MODEL DATA
solid_r20a.op3
Magnetostatic (TOSCA)
Nonlinear materials
Simulation No 1 of 1
23979099 elements
25707022 nodes
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Field Point Local Coordinates
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Model accomplishments

- Model defined with maximum steel cone consistent with PVDIS and SIDIS angular apertures.
- Provision made for mounting rails in cylinder within coil cryostat and on 90 cm OR cylinder joined to cone. No clearance on cone for mounts.
- Meshes developed which limit transverse forces in symmetric steel case under 1 kN and transverse torques under 100 kN-cm on superconducting coils. With 8-fold symmetry imposed, these are all zero.
- Forces and torques are within load cell limits.
- Model with service turret cut-out shows larger differences with symmetric model for first coil than second and third, as expected from geometry.

Stray field at entrance

- Thia Keppel suggested putting a single solenoid against the upstream plug.
- ~ 12 kAT in such a coil reduced stray field over He3 target to under one Gauss.
- Problem solved.
- kAT must be revisited when final steel is defined.

Forces and torques on steel parts, model with octagonal symmetry

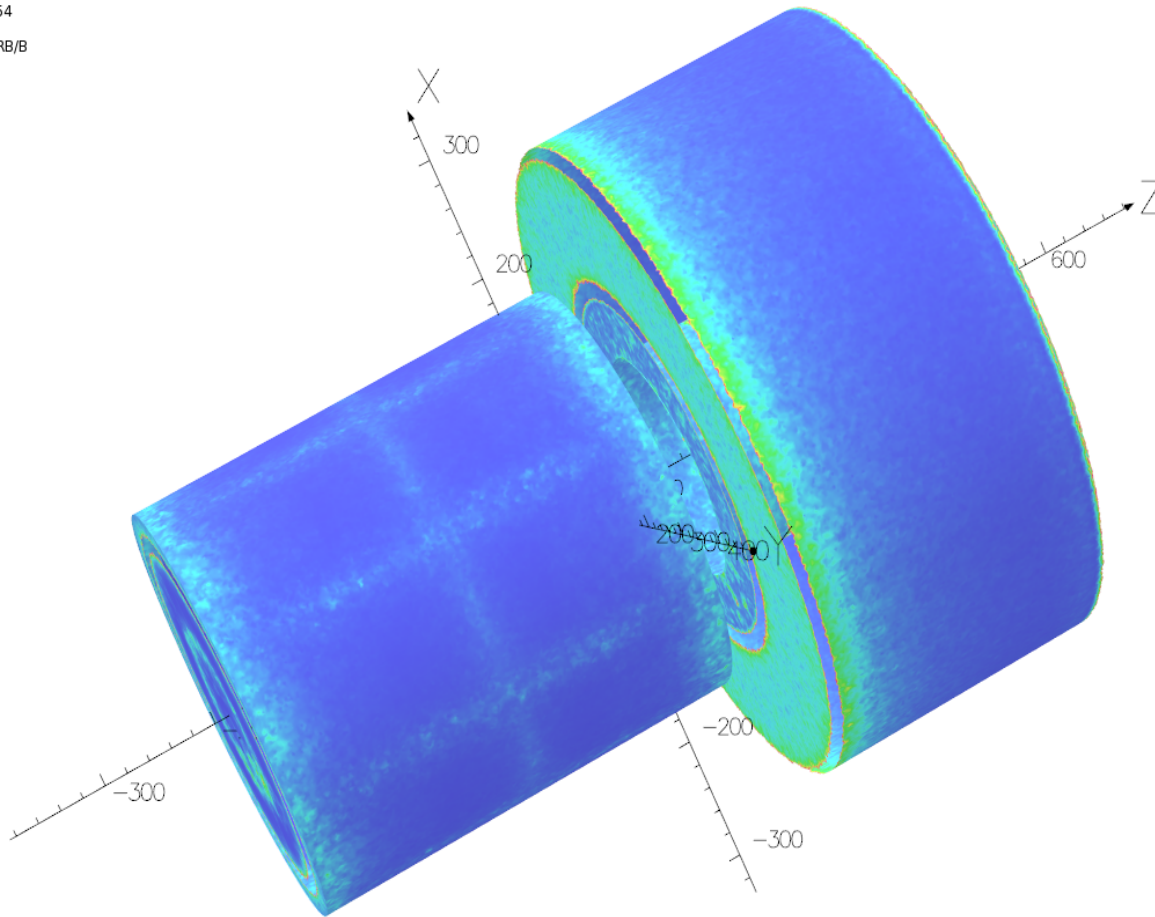
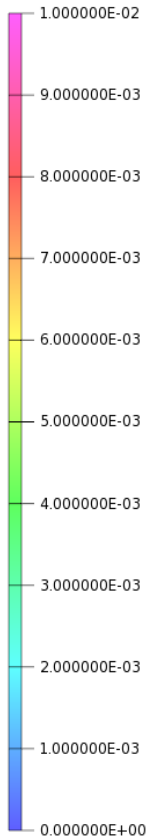
segment	Z force (N)	Z torque (N-cm) about (0,0,0)
cone	-2.29E6	6.89E4
endcap endplate	-1.46E6	1.53E4
endcap cylinder	-2.11E5	-80
downstream coil collar	-9.49E5	-1.97E5
octagons and endcap interface	2.13E6	-3.45E4
upstream coil collar	6.7E5	1.88E5
upstream plug	2.18E6	7.0E3

Z force coil 1	2.71E6 N
Z force coil 2	6.25E4 N
Z force coil 3	-2.8E6 N
Total force on coils	-2.34E4 N

Errors in detector volumes

28/Nov/2016 13:19:54

Surface contours: ERRB/B



UNITS

Length	cm
Magn Flux Density	gauss
Magnetic Field	oersted
Magn Scalar Pot	oersted cm
Current Density	A/cm ²
Power	W
Force	N

MODEL DATA

solid_r21c_detect_air_V18R2.op3
Magnetostatic (TOSCA)
Nonlinear materials
Simulation No 1 of 1
42956657 elements
63346223 nodes
3 conductors
Nodally interpolated fields
Activated in global coordinates

Field Point Local Coordinates

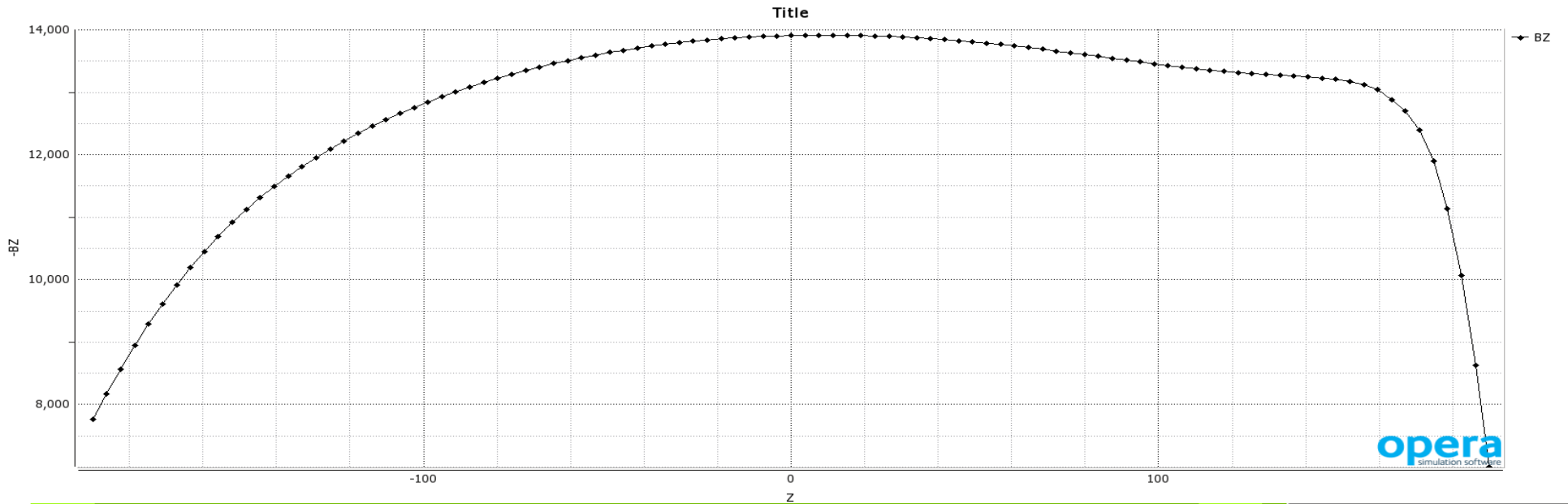
Local = Global

Opera
Simulation Software
COBHAM

Errors over 1% of local B field not shown

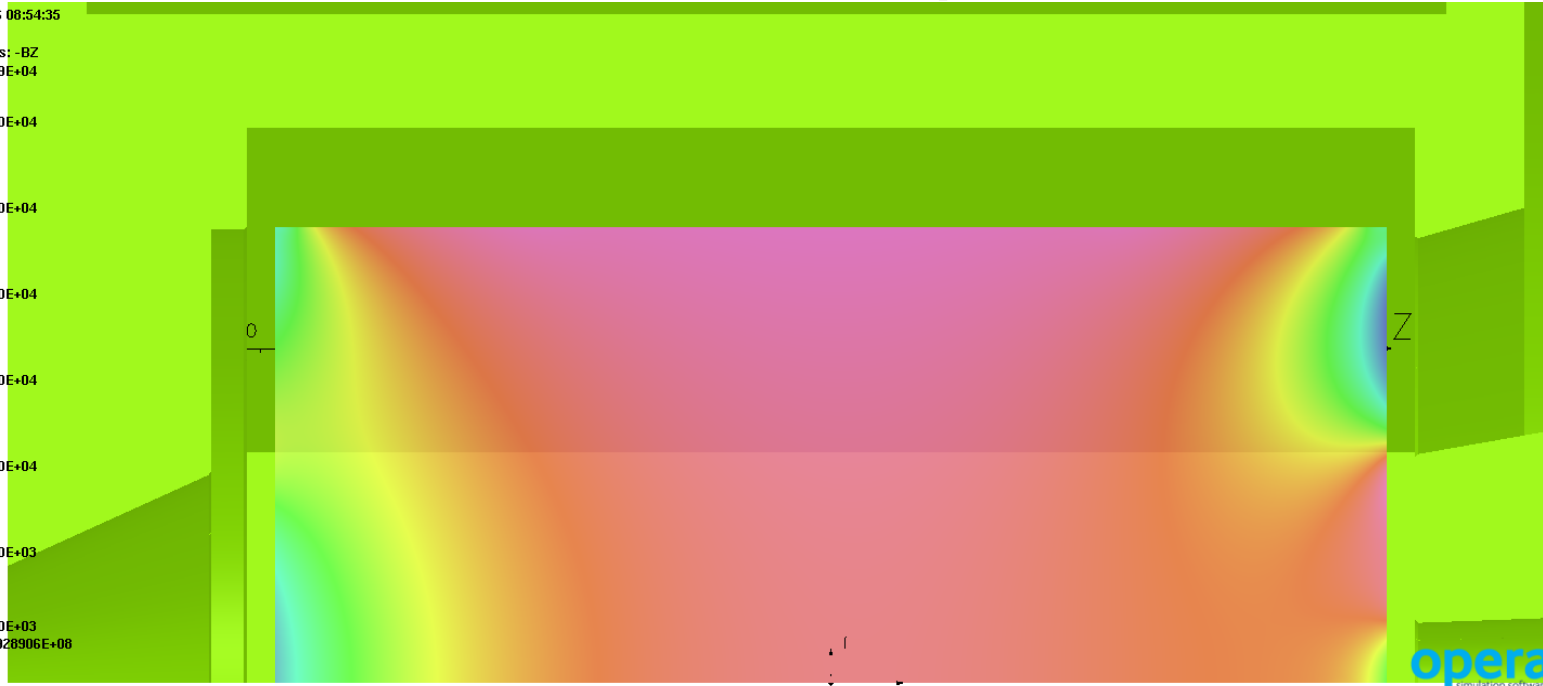
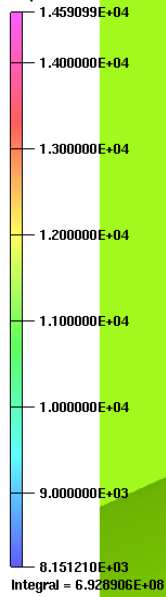
Questions

- Do I have to remove steel from cone, and therefore from upstream plug, to allow for detector mounts? Is 90 cm OR OK?
- What does “Endcap nose back reduce 5cm in r (EC hexagon module needs room)” mean? Give me a number.
- What interior length is needed for endcap cylinder? 261 cm now.
- Is longer/heavier cone compatible with What's overall endcap support and floor rail system?
- Can endcap cylinder wall be increased to 6.5” from 6” to lower stray field inside it?
- Can plate at end of cylinder be increased to 6.5” to reduce peak field in steel?
- Are field errors on previous page OK?



22/Oct/2016 08:54:35

Map contours: -BZ



UNITS			
Length		cm	
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Magn Scalar Pot		oersted cm	
Current Density		A/cm ²	
Power		W	
Force		N	

MODEL DATA			
solid_r20f_66cm_chamf.op3			
Magnetostatic (TOSCA)			
Nonlinear materials			
Simulation No 1 of 1			
23562323 elements			
25388102 nodes			
3 conductors			
Nodally interpolated fields			
Activated in global coordinates			
8-fold rotational symmetry			

Field Point Local Coordinates			
Local = Global			

FIELD EVALUATIONS			
Line	LINE (nodal)	101	Cartesian
	x=0.0	y=0.0	z=-190.0 to 190.0
Cartesian	CARTESIAN (nodal)	150x380	Cartesian
	x=0.0	y=0.0 to 145.0	z=-180.0 to 180.0

Bz fields in octagonal barrel, along axis (top) and YZ plane, bottom.